DOCUMENT RESUME

ED 033 504 EC 004 607

AUTHOR	Pendergast, Kathleen; And Others
TITLE	A Study of Protrusional Lisps to Identify Children Requiring Speech Therapy.
INSTITUTION	Seattle Public Schools, Wash.
Spons Agency	Office of Education (DHEW), Washington, D.C. Bureau of Research.
Bureau No	BR-5-0319
Pub Date	Jun 69
Contract	OEC-5-10-180
Note	71p.
EDRS Price	EDRS Price MF-$0.50 HC-$3.65
Descriptors	*Articulation (Speech), *Exceptional Child Research, Kindergarten Children, Performance Factors, *Prediction, Primary Grades, Speech Evaluation, Speech Handicapped, *Speech Improvement, Speech Skills, Speech Tests, Speech Therapy

Abstract

To determine factors influencing the permanency of a protrusional lisp and to incorporate them into predictive profiles, approximately 8,000 kindergarten children were screened for articulation and those appearing to have a protrusional lisp were tested individually. The 1,043 subjects exhibiting such a lisp were examined semiannually for 4 years with a battery of speech and other tests; their school records were assessed; no speech therapy was given. The data for the 475 subjects who remained, based on recovery and nonrecovery by the end of grade 3, were formulated into seven profiles, one for each testing period. The pattern indicated that no single test or subtest proved to be predictive at all periods. Results demonstrated a consistent increase in the number of subjects recovering, with 56% recovering without therapy. Higher recovery rates were found among subjects with a protrusional lisp only or with less severe articulation problems initially and more rapid reduction of errors throughout. Also, subjects producing [t,d,n,l] with the tongue tip and not the blade had a better chance to recover without therapy. (Author/JD)

PA-40
BR-50319
OE/BR

ED033504

FINAL REPORT

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June 1969

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U.S. DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE
Office of Education, Bureau of Research

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June, 1969

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ACKNOWLEDGMENTS

The investigators are indebted to the speech and hearing clinicians in the Seattle Public Schools for their careful administration and recording of the tests and examinations; to the dentists in the Department of Orthodontics, School of Dentristy, University of Washington, for their examinations of the subjects; to Alton W. Moore, D.D.S., and Richard A. Riedel, D.D.S., Chairmen, Department of Orthodontics, School of Dentistry, University of Washington, for their cooperation and support; to Dr. James A. Walsh, Associate Professor, Department of Psychology, Iowa State University, for the statistical treatment of the data; to John W. Selmar, Coordinator, Speech and Hearing, Lake Washington Schools, for participation in the initial phases of the study; to Helena Adamson, Supervisor of Special Education, and Louis Bruno, Superintendent of Public Instruction, State of Washington, for helping to negotiate the contract; to the principals of 88 Seattle elementary schools for their cooperation; to Roy Howard, Director of Special Education, and Frederick Breit, Deputy Superintendent, Seattle Public Schools, for their continuous support of the project. To each of these people, the investigators express most sincere gratitude.

SUMMARY

Background

Previous research has found that more children misarticulate the [s] than any other sound. A large number of defective [s] sounds are protrusional lisps. It is known that some children correct a lisp without speech therapy while others do not. If predictive instruments were available to identify those kindergarten and first grade children who will spontaneously correct a protrusional lisp without therapy, time could be used more profitably with those who will retain the lisp.

Objectives

The objectives of this study were to examine various factors which may influence the permanency of a protrusional lisp and to incorporate the significant factors into predictive profiles for retention or recovery.

Procedures

Approximately 8000 kindergarten children were administered an articulation screening test by specially trained speech clinicians employed by the Seattle Public Schools. Those children who appeared to have a protrusional lisp received an individual articulation test. A protrusional lisp was defined as any tongue protrusion anterior to the upper central incisors. The 1043 subjects who exhibited a protrusional lisp on the articulation test were examined semi-annually for the four years of the study with a battery of tests which included articulation, nonsense syllable, sound discrimination, tongue mobility, dental classification, swallow pattern, peripheral speech mechanism and diadochokinesis. In addition, the subjects were examined for muscular control, auditory acuity, psycholinguistic ability, social maturity, and intelligence. Reading readiness scores, achievement scores, school grades, and general health information were obtained from school records. Subjects did not receive speech therapy while they were enrolled in the study.

Results and Recommendations

At the end of the four years of periodic tests, 475 subjects remained in the study. The data, based on recovery and non-recovery from a protrusional lisp by the end of third grade, were formulated into profiles of tests and subtests. The seven profiles represented testing at six month intervals from the beginning of kindergarten through the beginning of third grade. The pattern of tests and subtests in the profiles indicated that no single test or subtest, by itself, proved to be predictive at all testing periods.

The results also permit some observations. A consistent increase in the number of subjects who had recovered was maintained through all the testing periods. In addition, the data showed that 56% of the

subjects had recovered from a protrusional lisp without speech therapy.

More subjects who had only a protrusional lisp recovered by the end of third grade than subjects who had a protrusional lisp along with errors on other sounds articulated with the tongue and sounds articulated with the lips.

Subjects in the recovery group tended to have a slightly less severe articulation problem when they began the study, as measured by the number of errors, and reduced the errors more rapidly than subjects in the non-recovery group.

The data showed that subjects with a protrusional lisp articulated [t, d, n, l] differently than usually described in the literature. Subjects at the beginning of kindergarten had a better chance to recover from a protrusional lisp without speech therapy if they produced [t, d, n, l] with the tongue tip rather than the tongue blade.

The profiles were compiled from the results of a group of testing instruments and were cross-validated on a subsample of the subjects. For further research, the profiles might be tested on other populations of kindergarten through third grade children to determine predictability of recovery and non-recovery from a protrusional lisp.

INTRODUCTION

Background

In a study of over 15,000 first grade children, it was found that more children misarticulated the [s] than any other sound (Pendergast et al., 1966). A large number of the defective [s] sounds were protrusional lisps. It is known that some children correct a lisp without speech therapy while others do not. But when children in kindergarten or first grade have a protrusional lisp, it is difficult to identify those who eventually will need speech therapy. Standardized criteria are needed to select those children who will not correct a protrusional lisp without speech therapy so that remedial measures may be started early. Also, if children who will correct a protrusional lisp without therapy could be identified, therapy time could be used more profitably with those who will retain the lisp.

Related Literature

Steer and Drexler (1960) said, "If it were possible to identify in kindergarten or first grade those children who would not achieve good articulation through the normal process of maturation, the problem of case selection would be greatly simplified." A need for predictive instruments has been generally acknowledged and some studies have attempted to identify these instruments (Carter and Buck, 1958; Farquhar, 1961; Pettit, 1957; Steer and Drexler, 1960; Irwin et al., 1966; Van Riper, 1966, 1968).

The research which has been conducted prior to the present study and subsequent to its inception has tested many factors which might be predictive. In a review of a number of these studies, Pronovost (1966) suggested that "...a battery of tests be used to assess all factors which have been clinically assumed to be causal factors in articulatory disorders." He also stated that, "Children who demonstrate average or above-average ability on the entire test battery should show significant improvement in articulation proficiency..."

These previous studies examined a variety of articulation problems, so it was felt that more precise predictions might be attained if the examination were limited to one articulation problem, the protrusional lisp. Therefore, in the present study, many of the factors generally considered to affect articulatory disorders were applied to children having a protrusional lisp.

Objectives

One objective of this study was to examine various factors which may influence the permanency of a protrusional lisp. Another was to incorporate significant factors into predictive profiles to identify those children who will and those who will not correct a protrusional lisp without speech therapy.

PROCEDURES

Experimental Design

Each of the approximately 8,000 kindergarten children in the Seattle Public Schools was administered an articulation screening test. Those children who appeared to have a protrusional lisp were administered an individual articulation test. Permission to take part in the study and background information through a questionnaire were obtained from the parents of those children who exhibited a protrusional lisp on the complete articulation test. The subjects were tested every October and April for four years with a battery of tests which included articulation, nonsense syllable, sound discrimination, tongue mobility, peripheral speech mechanism and diadochokinesis. An orthodontic examination which noted the dental classification and swallow pattern also were given every six months. The subjects were examined for muscular control, auditory acuity, psycholinguistic ability, social maturity, and intelligence. Reading readiness scores, achievement scores, school grades, and general health information were obtained from school records. All of the data was statistically treated by Professor James A. Walsh, Department of Psychology, Iowa State University. Subjects did not receive speech therapy while they were enrolled in the study.

Examiners

The examiners were speech clinicians employed by the Seattle Public Schools. One or more training sessions were conducted prior to administering the four standardized tests and each of the eight semi-annual administrations of the battery of tests. Each speech clinician was provided with a manual of test instructions for this battery of tests. The instructions for all tests were read, demonstrated, and discussed. In addition to these formal training sessions, all speech clinicians new to the staff each year were advised, six weeks prior to the testing period, of the kinds of judgments they would be required to make.

Interrater reliability for the articulation testing was established with the Photo Articulation Test (PAT). Five randomly selected examiners judged the same articulation responses of fifteen children. As each child responded to a PAT picture, the examiners made an independent judgment and scored it on a recording sheet which was not visible to the other examiners. Using this method, mean interrater reliability was .988.

Subject Selection

This study was begun in October, 1964, with the selection of subjects from the kindergarten population of the 88 elementary schools of the Seattle Public Schools. Because many first graders have

missing incisors*, it was necessary to initiate the study with subjects who were beginning kindergarten and who had not lost their deciduous teeth. Children who were repeating kindergarten were excluded. A speech screening test sentence for subject selection was given to 7,931 kindergarten children. The sentence, "She lives in a little red house with her brothers and sisters," was an adaptation of the screening sentence used in previous research (Pendergast et al., 1966). The original sentence, "She lives in a little red house with her brother, Gary, and her sister, Kay," was validated by one examiner screening 52 first grade children with the sentence and a second examiner administering the Bryngleson-Glaspey Test to the same 52 children. No children were found by the Bryngleson-Glaspey Test who had not already been identified as having [s-z] errors by the screening sentence. To shorten the sentence for kindergarten children and to include two more [z] sounds, the words "Gary" and "Kay," were omitted and "brother" and "sister" were pluralized. Each child was asked to say this sentence according to Instructions for Administering the Screening Test, PL-3a (Appendix A). Any child who appeared to have a protrusional lisp on one or more of the [s-z] sounds in the sentence was tested on the first 6 items of the PAT as described in Instructions for Administering the First Photo Articulation Test, PL-3b (Appendix A). For the purposes of this study, a protrusional lisp was defined as any tongue protrusion anterior to the upper central incisors. This screening and testing procedure identified 1,043 children (13%) with a protrusional lisp.

A letter, PL-1 (Appendix A), requesting approval for each child to participate in the study, was sent to the parents of all the children who had a protrusional lisp. There were 98 parents who did not respond and 51 who did not give their approval. There remained 894 children at the beginning of the first series of periodic tests.

During the four years of the study, some children moved from the city, transferred to private schools, were absent for one of the many periodic tests or for various reasons could not be included in the final group of 475 subjects for whom all tests and examinations were complete. A summary of subject attrition for the entire term of the study is found in Appendix B.

Of the 475 subjects, 221 were girls and 254 were boys. Their age range at the beginning of the study was four years ten months to six years eight months with a mean of five years five months. The distribution according to race was: Caucasian 368, Negro 69, Oriental 32, and other 6.

* Snow (1961) found that more first grade children with defective or missing upper central incisors misarticulated the [s-z] than did children with normal teeth.

TESTS, EXAMINATIONS, AND SUBJECT INFORMATION

Articulation Test

Research by Snow and Milisen (1954), examining the difference between pictorial and imitative presentation of the stimuli for articulation testing, indicated that "...the picture, not the oral, test should be preferred when testing the articulation of children." This finding was supported by Siegel, Winitz, and Conkey (1963) and Carter and Buck (1958). An experimental edition of the Photo Articulation Test (PAT) (Pendergast et al., 1969), which is a pictorial presentation of stimuli, was chosen because the photographs were more readily recognized by kindergarten children than tests using pictures with line drawings.

The test was administered according to Instructions for Administering the Photo Articulation Test, PL-3c (Appendix A). Misarticulations were recorded on the Photo Articulation Test form, PL-3 (Appendix A).

It has been recognized that error sounds are not consistently misarticulated but may be correctly produced at times. This inconsistency of articulation has been noted by Van Riper and Irwin (1958), Templin and Darley (1960), McDonald (1964), and Baer and Winitz (1968). Historically, it has been assumed that the frequency of correct articulations of a sound would predict its probable generalization to all positions and contexts. Therefore, if a sound is articulated correctly in most contexts, the sound would be learned without speech therapy. However, Baer and Winitz (1968) found their low-error and average-error groups "...showed similar acquisition and performance rates of the [v] sound with repeated sound stimulation." Error frequency did not account for the similarity in learning. It should be pointed out that this conclusion was based on a change after a period of prescribed training and does not necessarily preclude the assumption that consistency of articulation is a predictor of sound learning without training.

Nonsense Syllable Test

The ability to imitate nonsense syllables containing the sound misarticulated on a pictorially presented articulation test has proved to be a fairly reliable predictive factor in previous research. Carter and Buck (1958) reported, "In using the Nonsense-syllable type test as compared with the Spontaneous Test, the speech therapist might expect that those children who make no correction on this test will need therapy to correct their misarticulations." In her predictive study, Farquhar (1961) reaffirmed these findings and concluded, "The results of this study suggest that the speech clinician may utilize the imitation of words and nonsense syllables as prognostic tools." A nonsense syllable test was included in this study to determine its predictability on the permanency of a protrusional lisp.

A test similar to, but shorter than, the Carter and Buck was formulated. This was accomplished by limiting the test to only one vowel [α] rather than three vowels as in the Carter and Buck. This test was constructed so the order of syllables was the same as the order of sounds on the PAT. The examiner tested only the items corresponding to the misarticulated sounds on the PAT. Instructions for Administering the Nonsense Syllable Test PL-4a and recording form PL-4 are in Appendix A.

Sound Discrimination Test

Research to examine the relationship between auditory discrimination ability and articulation ability has indicated equivocal conclusions. The findings of Cohen and Diehl (1963), Kronvall and Diehl (1954), Farquhar (1961), Schiefelbusch and Lindsey (1958), Sherman and Geith (1967), Weiner (1967), and Wepman (1960) showed significant relationships between discrimination and articulation, while those of Aungst and Frick (1964), Hansen (1944), and Prins (1963) did not.

A survey of the literature by Powers (in Travis, 1957) showed that "...studies on speech-sound discrimination as related to articulation skill are seen to be conflicting and inconclusive." She indicated that "...the great weight of evidence is against there being a systematic inferiority of functional articulatory defectives in ability to discriminate speech sounds."

Other authors have considered auditory discrimination ability as a possible predictor of articulation improvement. Dickson (1962) suggested that speech-sound discrimination ability has minimal value in predicting spontaneous elimination of articulation errors. However, Pronovost (in Webster et al., 1966) "...found very few children with misarticulations who had low auditory discrimination scores, but when both abilities were low there was less tendency for articulatory proficiency to improve."

A sound discrimination test was included in the battery of tests because of its possible value as a predictor of either retention or recovery from a protrusional lisp. The standard tests were not used because of interest in only the subject's ability to discriminate the sibilant sounds along with [θ] and [ð]. A test was devised similar to that used by Pendergast (1952) in which "Each consonant phonetic element was matched with another acoustically similar consonant phonetic element, with two acoustically different consonant phonetic elements and with itself." The present adaptation was limited to fifteen pairs of consonant phonetic elements combined with [α]. The five different sibilant pairs were arranged in an increasing order of discrimination difficulty and the [θ] and [ð] pairs were added. The eight similar pairs were randomly interspersed with the seven different pairs. This test was administered verbally to each subject individually in the manner described in Instructions for Administering the Sound Discrimination Test, PL-5a (Appendix A) and recorded on PL-5 (Appendix A).

Tongue Tip Examination

Standard classifications describe the involvement of the tongue and alveolar ridge in the production of certain sounds. For the production of [t, d], Carrell and Tiffany (1960) note that "...the tonguetip is placed on the alveolar ridge behind the upper central teeth, and the lateral margins of the tongue are in contact with the teeth and gums in such a way as to form an airtight closure." Similarly, for [n] production, "...the tonguetip is placed on the alveolar ridge, with the sides of the tongue in contact with the teeth and gums." Also, [l] ".. is made with the tonguetip against the alveolar ridge, but with the tongue adjusted in such a manner that its margins do not touch the teeth and gums at the sides."

However, therapy experience has shown that children with a protrusional lisp sometimes produce acoustically acceptable [t, d, n, l] with the tongue blade as they place the tongue tip either anterior to the upper central incisors or posterior to the lower central incisors. The tongue and alveolar ridge are used in the production of both [t, d, n, l] and [s, z]. It was decided to investigate the production of [t, d, n, l] in this study because of the possibility that their manner of production might be of value in predicting retention of a protrusional lisp or the development of normal [s, z].

Four short sentences were designed so the subject's tongue positions for his production of [t, d, n, l] could be observed. To facilitate observations of tongue positions, words containing sounds such as [p, b, m] which would have obstructed the examiner's view were excluded. Each sentence was constructed so the sound being tested either initiated the sentence, ended the sentence, or was preceded and followed by a vowel. Antero-postero tongue tip position was judged as described in the Instructions for Administering the Tongue Tip Examination, PL-6a, and recorded on Tongue Tip Examination Form, PL-6 (Appendix A).

Speech Mechanism Examination

In many studies, subjects are excluded because of various physical anomalies of the peripheral speech mechanism. However, some children with a protrusional lisp have these anomalies and must be included in the therapy program. Therefore, in the present study, subjects with tongue, palate, and alveolar ridge deviations were not excluded so the effect of these factors upon the permanency of a protrusional lisp could be examined.

Accepted diagnostic procedures include the examination of the attachment of the frenum because of its possible effect on tongue mobility. Even though acoustically acceptable production of [s, z] is commonly found in children with various degrees of frenum attachment, it was thought that the ability to elevate the tongue might have a value in predicting the permanency of a protrusional lisp.

Gross judgments of palate shape and alveolar ridge width were included in the Speech Mechanism Examination because the palate and ridge are involved in the production of [s, z].

Evidence in the literature shows the relationship between visceral swallowing patterns and deviant production of certain speech sounds. Ward et al. (1961) stated that "...visceral swallowing in children with sound distortions at the first grade level may well have predictive value.... (It) may be a complicating factor interfering with the normal development of tongue-tip phonemes." The results of a study by Fletcher, Casteel, and Bradley (1961), "...indicated that the subject with a tongue-thrust swallow was much more likely to have associated sibilant distortion than was the subject without this pattern of swallowing." Because of this relationship between swallow patterns and sound production, along with the possibility of swallow characteristics being a predictor of change in sibilant sound production, an examination for facial grimace and tongue protrusion during a swallow was indicated.

The ability to move tongue and lips is important in the production of [s, z]. Tests of diadochokinesis were formulated to investigate the possible relationship of this ability to the retention of a protrusional lisp. Mase (1946) compared fifth and sixth grade articulatory defective boys with normal speakers on several actions of the speech mechanism. He found no significant differences between the two groups on any of these tests. A report by Pronovost (in Webster et al., 1966) indicates that "Children who were unable to execute rapid, rhythmical movements of the tongue (in-out, side to side, tapping alveolar ridge, etc.), or whose movements were sluggish, tended to show less progress in articulatory development."

Therefore, degree of frenum attachment, palate shape, alveolar ridge width, facial grimace and tongue protrusion during a swallow, and diadochokinetic abilities were judged according to instructions for administering the Speech Mechanism Examination, PL-7a, and recorded on PL-7 (Appendix A).

Orthodontic Examination

Snow (1961) studied the relationship of certain sounds, including [s, z] to the condition of the upper incisors. She found a greater number of children misarticulated these sounds when they had missing or abnormal upper incisors. However, she pointed out that 70% of the children with missing or abnormal incisors correctly articulated the [s].

Bankson and Byrne (1962) tested the influence of missing teeth on [s, ʃ, f, z]. They found no statistically significant relationship between the presence or absence of teeth among children who produced the sounds incorrectly before the loss of their deciduous teeth. Because the present research was designed to study protrusional lisps, an investigation was made of the presence or absence of teeth for their possible predictive value.

Jann et al. (1964) states "...we can note that malocclusion appeared so frequently in the population studied that it merits consideration as the statistical norm." To investigate further the nature of malocclusions, the present study included measurements of overbite, overjet, and openbite to determine their possible influence on the retention of a protrusional lisp.

A pedodontist and two speech clinicians (Ward et al., 1961) studied the articulation, swallow pattern, and teeth of 358 children in grades 1-3. Subtelny and Subtelny (1962), an orthodontist and a speech clinician, studied subjects with the Class II, division 1 type of malocclusion to explore normal protrusive tongue habits during speech and swallowing in relation to this type of malocclusion. The present study also included dental classifications made by dental specialists. The Dean of the School of Orthodontics, University of Washington, formulated Orthodontic Examination, PL-8 (Appendix A), for the recording of judgments by practicing dentists enrolled in the School of Orthodontics.

Audiometric Test

Historically, hearing acuity has been assumed to be related to articulation proficiency. Because the present study was designed to examine any factor which might influence the permanency of a protrusional lisp, subjects with hearing losses were not excluded.

The subjects were screened for hearing at 25 decibels (ISO) for 500 cycles and 20 decibels (ISO) for 2000 and 4000 cycles either by the audiologist or the audiometrist of Seattle Public Schools as a part of the routine screening of first grade children. Any child who failed the screening was given a full scale audiometric examination. Of the 475 subjects, 35 (7.4%) had a mild to moderate hearing loss in one or both ears, but these subjects were not excluded.

The Oseretsky Tests of Motor Proficiency

Previous research as presented by Jenkins and Lohr (1964) has pointed out conflicting conclusions regarding the relationship between motor ability and articulation disorders. However, in their study, they found that "...children with severe articulation defects do on the average have more difficulty in motor proficiency, as measured by the Oseretsky tests, than do children without severe articulation disorders." Dickson (1962) found that "Children who had outgrown speech errors... were able to complete significantly more motor tasks successfully than those who had not outgrown their speech errors...." He proposed "...that a gross motor deficit may be related to articulation errors but may not necessarily be manifested in isolated fine motor functions...."

For the present research, a pilot project on the Oseretsky Tests of Motor Proficiency was designed. Comparisons were made between three testing procedures: (a) the complete test as described in the manual, (b) the level corresponding to the subject's age and the

levels immediately preceding and following his age, and (c) the subject's age level only. Procedures (a) and (b) proved to be excessively time consuming because each test took from one to two hours. This pilot project also showed that levels other than the subject's age level added no significant information to the motor performance evaluation. Therefore, only the age level of each subject was tested. Dickson (1962) also found it appropriate to abbreviate the Oseretsky tests in his research to determine differences between children who had retained articulation errors and those who had not.

General Information on the Oseretsky Tests (Appendix A) was developed to clarify testing procedures given in the Doll translation of the manual from Portuguese to English. Conversions of metric system lengths to equivalent feet and inches were included.

In the study by Jenkins and Lohr (1964), "...the speed tests proved insensitive and were dropped from the test battery after they were failed by the first eighteen children tested, including experimental and control subjects...." Similarly, in the present study, only two of the subjects were able to do the motor speed task corresponding to their age levels, according to the interpretation of the manual. Therefore, the motor speed category was excluded when the total score was determined.

Vineland Social Maturity Scale

In order to investigate the possible effect that social maturity might have on the retention of a protrusional lisp, the Vineland Social Maturity Scale was administered during the third year of the study. The items related to the several age levels were examined for adaptation to the population being tested. Items in the various categories assigned to the IV-V age level were commonplace for second grade children enrolled in public schools. Items in the XV-XVIII level were too advanced to give meaningful information to the scores. It was decided, therefore, to base each subject's maturity score on those items in levels V-VI through XII-XV.

Information was obtained by interviewing the subjects. Doll, in the Manual of Directions, states that "Under favorable conditions the Scale may be administered with the subject of the examination acting as his own informant. This has been found practicable with normal children as young as five years of age..."

A supplement, Instructions for Administering Vineland Social Maturity Scale (Appendix A), was developed to facilitate the use of the Manual of Directions and to standardize interpretation, scoring symbols, and testing procedures. In scoring, credit was arbitrarily given for all items prior to level V-VI. Each subject's score was a total of this prior credit and the score on the tested items. This was converted to a social age by using the Manual of Directions.

Peabody Picture Vocabulary Test

Intelligence has been accepted as a factor relating to articulatory development. Pronovost (in Webster et al., 1966) recommended that non-verbal items be included in a test of intellectual functioning as a part of a test battery to choose candidates for speech therapy. The Peabody Picture Vocabulary Test (PPVT) requires a non-verbal response on the part of the subject. Dunn (1959) in the manual for the PPVT states "The administration... requires no special preparation other than complete familiarity with the test materials, including practice in giving the instrument prior to its use as a standardized measure." In the present research, the PPVT was included as a possible predictor of retention of a protrusional lisp. Form "B" of the test was adminstered and scored according to the instructions in the manual.

Illinois Test of Psycholinguistic Abilities

Bateman (1964) presented a summary of studies on the Illinois Test of Psycholinguistic Abilities (ITPA) in current research. Two of these summaries reported the application of the ITPA to the articulation of normal children. Foster (1963) found that "Children with persistent speech disorders performed significantly lower than the controls (raw score means) on the following subtests: Auditory-Vocal Automatic, Auditory-Vocal Sequential, Visual-Motor Sequential, Visual Decoding, Visual-Motor Association, and Vocal Encoding." Ferrier (1963) noted that "Children with functional defects of articulation scored significantly lower than children without these defects on the three ITPA subtests at the automatic-sequential level and on the auditory-vocal channel subtests at the representational level." These studies suggested that some subtests of the ITPA might show value for inclusion in a predictive profile of retention of a protrusional lisp. The ITPA was given by qualified examiners according to the Examiner's Manual.

Questionnaire and School Record Information

A background information questionnaire, PL-2 (Appendix A), was included in the first testing period. The parent provided the subject's history. The father's occupation was classified according to the Minnesota Scale for Paternal Occupations. Birthplaces were divided by regions according to Kenyon and Knott (1949).

Additional information on each subject was obtained from school records. Scores for Metropolitan Readiness Tests, The Lorge-Thorndike Intelligence Tests, and Metropolitan Achievement Tests, along with academic, social, psychological, health, and attendance information were recorded on form PL-9 (Appendix A) in accordance with Instructions for School Record Information, PL-9a (Appendix A).

TREATMENT OF THE DATA

The 475 subjects remaining in the study at the completion of the last testing in third grade were randomly divided into an analysis sample of 250 subjects and a cross-validation sample of 225 subjects. The analysis group was composed of a recovery group of 145 subjects (73 boys and 72 girls) and a non-recovery group of 105 subjects (64 boys and 41 girls). The cross-validation sample had a recovery group of 121 subjects (59 boys and 62 girls) and a non-recovery group of 104 subjects (55 boys and 49 girls). The statistician's treatment of the analysis and cross-validation samples for the development of predictive profiles is described in detail in "Statistical Methodology and Analysis," Appendix C.

RESULTS AND DISCUSSION

Seven "profiles"* to predict recovery and non-recovery from a protrusional lisp were formulated. The first profile represented testing early in kindergarten. Subsequent profiles represented testing at six month intervals, October and April, through the beginning of third grade. Successful prediction of recovery and non-recovery by the end of third grade was the goal of the profiles.

The percentages of correct prediction for the analysis sample and the cross-validation sample are given on the profiles. The percentages of prediction increased at each successive testing period. The profile for beginning kindergarten correctly predicted for 62.0 percent of the cases in the analysis sample and 53.3 percent in the cross-validation sample. However, for the profile at the beginning of the third grade, the correct prediction had increased to 87.2 percent and 84.0 percent, respectively.

Seven subtests from the PAT, two from the Orthodontic Examination, two from the Speech Mechanism Examination, along with the unlike items from the Sound Discrimination Test, the correct responses on the [s-z] items on the Nonsense Syllable Test, and the total score on the Tongue Tip Examination made up the predictive profiles. Each profile was predictive at only one testing period.

The Photo Articulation Test, or sections of it, was a part of the group of predictors for every testing period.

The Nonsense Syllable Test was a part of the profile for the end of first grade.

Part of the Sound Discrimination Test was in the predictive profile only for the beginning of kindergarten. The whole test included responses to sibilant pairs which were either the same or

* The term is not used in its usual sense but, instead, refers to the tabular presentation of regression analyses.

different, but only the responses to the different items were predictive.

Sections of the Speech Mechanism Examination appeared in the profiles for three testing periods. The score on the test of lateral tongue movement at the end of first grade and judgments of swallow characteristics at both the beginning and end of second grade were parts of the profiles.

Parts of the Orthodontic Examination appeared in the predictive profiles for three testing periods. The judgment of the facial grimace at the beginning of kindergarten was predictive. Openbite was part of the profiles at the end of second grade and the beginning of third grade.

Several tests did not appear in the profiles. These were the Oseretsky Tests of Motor Proficiency, Vineland Social Maturity Scale, Peabody Picture Vocabulary Test, Illinois Test of Psycholinguistic Abilities, and the audiometric test. Also, none of the information from the school records or the parent questionnaire was in any of the profiles.

The profiles are Tables 1 through 7. These profiles were applied to each subject in the study. For example, on Table 1, the first subtest was from the PAT, items 1-9. The possible error range was 0 to 9. The number of errors for each subject was multiplied by .070, the raw score regression weight, which resulted in a possible range of scores from 0. to .630. The second subtest was the grimace from the Orthodontic Examination. The possible score was either "1" if the subject had a grimace, or "2" if he had no grimace. This number was multiplied by -.147, the raw score regression weight, which resulted in a possible range of scores from -.294 to -.147. The third subtest was the unlike items from the Sound Discrimination Test. The possible number of correct responses was 0 to 7. This was multiplied by -.037, the raw score regression weight, which resulted in a possible range of scores from -.259 to 0. These three scores were added to .254, the intercept value. This produced the profile score range, -.299 to .737. The raw score cutoff from Table 1 was .44. For subjects whose scores were more than .44, non-recovery was predicted and for subjects whose scores were less than .44, recovery was predicted. This prediction was correct for 62.0% of the subjects in the analysis sample and 53.3% in the cross-validation sample.

The subjects who had more* omissions, substitutions, and distortions of [s-z]; who had a facial grimace when they swallowed; and

* It is not possible to give exact scores for each item on most profiles because a variety of individual scores will result in a total score above or below the cutoff. Therefore, the terms "more" and "fewer" seem appropriate. In this context, these terms refer to a comparison of the recovery and non-recovery groups.

who were unable to identify many unlike sounds as being different were less likely to recover from a protrusional lisp than subjects who had fewer omissions, substitutions, and distortions of [s-z]; no facial grimace when they swallowed; and good sound discrimination.

TABLE 1. Profile for the Beginning of Kindergarten.

Test or Subtest	Scoring	Raw Score Regression Weight		Possible Range of Scores
Items 1-9, Photo Articulation Test (PAT)	Count errors (0-9)	.070	0.	to .630
Grimace, Orthodontic Exam	Judge grimace 1-grimace 2-no grimace (1-2)	-.147	-.294	to -.147
Sound Discrimination Test	Count correct responses on unlike items 2, 3, 5, 9, 10, 13, 15 (0-7)	-.037	-.259	to 0.
	x x x x x x			
	Intercept Value	.254		.254
	Profile Score Range	-.299	to	.737
	Raw Score Cutoff		.44	

Correct Predictions
Analysis Sample 62.0%

Cross-Validation Sample 53.3%

At the end of kindergarten, the profile (Table 2) contained a single predictor, the score on the first nine items of the PAT.

TABLE 2. Profile for the End of Kindergarten.

Test or Subtest	Scoring	Raw Score Regression Weight		Possible Range of Scores
Items 1-9, PAT	Count errors (0-9)	.056	0.	to .504
		x x x x x x		
	Intercept Value		-.023	-.023
	Profile Score Range		-.023	to .481
	Raw Score Cutoff		.47	

Correct Predictions
Analysis Sample 58.0%
Cross-Validation Sample 62.7%

Subjects who had nine omissions, substitutions, or distortions on the nine [s-z] test words were less likely to recover from a protrusional lisp without speech therapy than subjects who misarticulated eight or less of the nine test words.

The predictive profile for the beginning of first grade (Table 3) included three subtests of the PAT. These were the substitution score for the [s-z] items, the total score for all sounds tested in the final position, and the substitution score for the final position of [s-z].

TABLE 3. Profile for the Beginning of First Grade.

Test or Subtest	Scoring	Raw Score Regression Weight	Possible Range of Scores
Items 1-9, PAT	Count substitutions (0-9)	.088	0. to .792
Final items, PAT	Count errors (0-20)	.040	0. to .800
Items 3 and 6, PAT	Count substitutions (0-2)	-.173	-.346 to 0.

x x x x x x

Intercept Value	.095	.095
Profile Score Range	-.251 to 1.687	
Raw Score Cutoff	.47	

Correct Predictions
- Analysis Sample 66.4%
- Cross-Validation Sample 70.2%

Subjects who had more substitutions on the nine [s-z] test words; who had an omission, substitution, or distortion on many of the twenty words which test each sound in the final position; and who did not have a substitution on either of the words which test [s-z] were less likely to recover from a protrusional lisp without speech therapy than subjects who had fewer substitutions on the nine [s-z] test words; more correct articulation of all sounds in the final position; and substitutions on final [s-z].

At the end of first grade, subtests from three examinations formed the profile (Table 4). The subtests of the PAT were the total errors on the first nine items and the errors on the two [s-z] items tested in the final position. The other subtests in the profile were the correct responses to the [s-z] items from the Nonsense Syllable Test and the lateral tongue movement score from the Speech Mechanism Examination.

TABLE 4. Profile for the End of First Grade.

Test or Subtest	Scoring	Raw Score Regression Weight	Possible Range of Scores
Items 1-9, PAT	Count errors (0-9)	.123	0. to 1.107
Items 1-5, Nonsense Syllable Test	Count correct responses (0-15)	-.019	-.285 to 0.
Items 3 and 6, PAT	Count errors (0-2)	-.196	-.392 to 0.
Lateral Tongue Movement, Speech Mechanism Exam	Total score (0-30)	-.010	-.300 to 0.
	x x x x x x		
	Intercept Value	.239	.239
	Profile Score Range		-.738 to 1.346
	Raw Score Cutoff		.50
Correct Predictions			
Analysis Sample		73.6%	
Cross-Validation Sample		69.8%	

Subjects who had more omissions, substitutions, or distortions on the nine [s-z] test words; did not misarticulate either of the words testing [s-z] in the final position; were unable to repeat correctly the nonsense syllables testing [s-z]; and were unable to move their tongue quickly from one corner of the mouth to the other were less likely to recover from a protrusional lisp than children who had fewer omissions, substitutions, or distortions of the nine [s-z] test words; had misarticulations on the two words testing [s-z] in the final

position; were able to repeat correctly the nonsense syllables testing [s-z]; and could move their tongue more rapidly from one corner of the mouth to the other.

Three subtests of the PAT and a subtest of the Speech Mechanism Examination formed the profile (Table 5) for the beginning of the second grade. The PAT subtests were the total errors on the first nine items, the total omissions for the tongue sounds, and the errors on the two [s-z] items tested in the final position. The subtest of the Speech Mechanism Examination was the swallow score.

TABLE 5. Profile for the Beginning of Second Grade.

Test or Subtest	Scoring	Raw Score Regression Weight	Possible Range of Scores
Items 1-9, PAT	Count errors (0-9)	.055	0. to .495
Swallow, Speech Mechanism Exam	Judge swallow 2-No grimace-No protrusion 3-Grimace-No protrusion 4-No grimace-Protrusion 5-Grimace-Protrusion	.076	.152 to .380
Tongue items, PAT	Count omissions on items 10-46 and 53-60 (0-45)	.183	0. to 8.235
Items 3 and 6, PAT	Count errors (0-2)	.051	0. to .102
	x x x x x x		
	Intercept Value		-.201 -.201
	Profile Score Range		-.049 to 9.011
	Raw Score Cutoff		.48
Correct Predictions Analysis Sample	76.4%		
Cross-Validation Sample	72.6%		

Subjects who had more omissions, substitutions, or distortions on the nine words testing [s-z] and the two words testing [s-z] in the final position; protruded the tongue and grimaced when they swallowed; and had omissions on sounds articulated with the tongue [ʃ, ʒ, tʃ, dʒ, t, d, n, l, θ, ð, r, k, g, ŋ] were less likely to recover from a protrusional lisp than subjects who had fewer omissions, substitutions or distortions on the nine words testing [s-z] and the two words testing [s-z] in the final position; did not protrude the tongue or grimace when they swallowed; and had fewer omissions on sounds articulated with the tongue.

At the end of the second grade, two subtests from the PAT, one from the Speech Mechanism Examination, and one from the Orthodontic Examination combined as the predictive profile (Table 6). The PAT subtest scores included the errors on the first nine items and the total of all substitutions. The swallow score from the Speech Mechanism Examination, along with the openbite judgment from the Orthodontic Examination completed the profile.

Subjects who had more omissions, substitutions, or distortions on the nine words testing [s-z]; had more substitutions on the entire articulation test; protruded the tongue and grimaced when they swallowed; and had an openbite were less likely to recover from a protrusional lisp than subjects who had fewer omissions, substitutions, or distortions on the nine words testing [s-z]; had fewer substitutions on the entire articulation test; did not protrude the tongue or grimace when they swallowed; and had a normal bite.

TABLE 6. Profile for the End of Second Grade.

Test or Subtest	Scoring	Raw Score Regression Weight	Possible Range of Scores
Items 1-9, PAT	Count errors (0-9)	.050	0. to .450
PAT	Count substitutions (0-72)	.023	0. to 1.656
Swallow, Speech Mechanism Exam	Judge swallow 2-No grimace-No protrusion 3-Grimace-No protrusion 4-No grimace-Protrusion 5-Grimace-Protrusion	.055	.110 to .275
Openbite, Orthodontic Exam	Judge openbite 1. 0 mm. 2. 0-2 mm. 3. 2+ mm.	.061	.061 to .183
	x x x x x x		
	Intercept Value	-.192	-.192
	Profile Score Range		-.021 to 2.372
	Raw Score Cutoff		.44

Correct Predictions

Analysis Sample	80.8%
Cross-Validation Sample	82.2%

The profile for prediction at the beginning of third grade (Table 7) included the errors on the first nine items of the PAT, the total substitutions on the first nine items on the PAT, the openbite judgment from the Orthodontic Examination, and the score on the Tongue Tip Examination.

TABLE 7. Profile for the Beginning of Third Grade.

Test or Subtest	Scoring	Raw Score Regression Weight	Possible Range of Scores
Items 1-9, PAT	Count errors (0-9)	.051	0. to .459
Items 1-9, PAT	Count substitutions (0-9)	.044	0. to .396
Openbite, Orthodontic Exam	Judge openbite 1. 0 mm. 2. 0-2 mm. 3. 2+ mm.	.064	.064 to .192
Tongue Tip Exam	Total score (4-8)	.030	.120 to .240
	x x x x x x		
	Intercept Value	-.164	-.164
	Profile Score Range		.020 to 1.123
	Raw Score Cutoff		.42

Correct Predictions

Analysis Sample 87.2%

Cross-Validation Sample 84.0%

Subjects who had more misarticulations and also substitutions on the nine words testing [s-z]; had an openbite; and articulated [t, d, n, l] with the tongue blade were less likely to recover from a protrusional lisp without speech therapy than subjects who had fewer misarticulations and substitutions on the nine words testing [s-z]; had a normal bite; and articulated [t, d, n, l] with the tongue tip.

Figure 1 shows the pattern of tests and subtests in the profiles. When factors other than the first nine items of the PAT appeared in

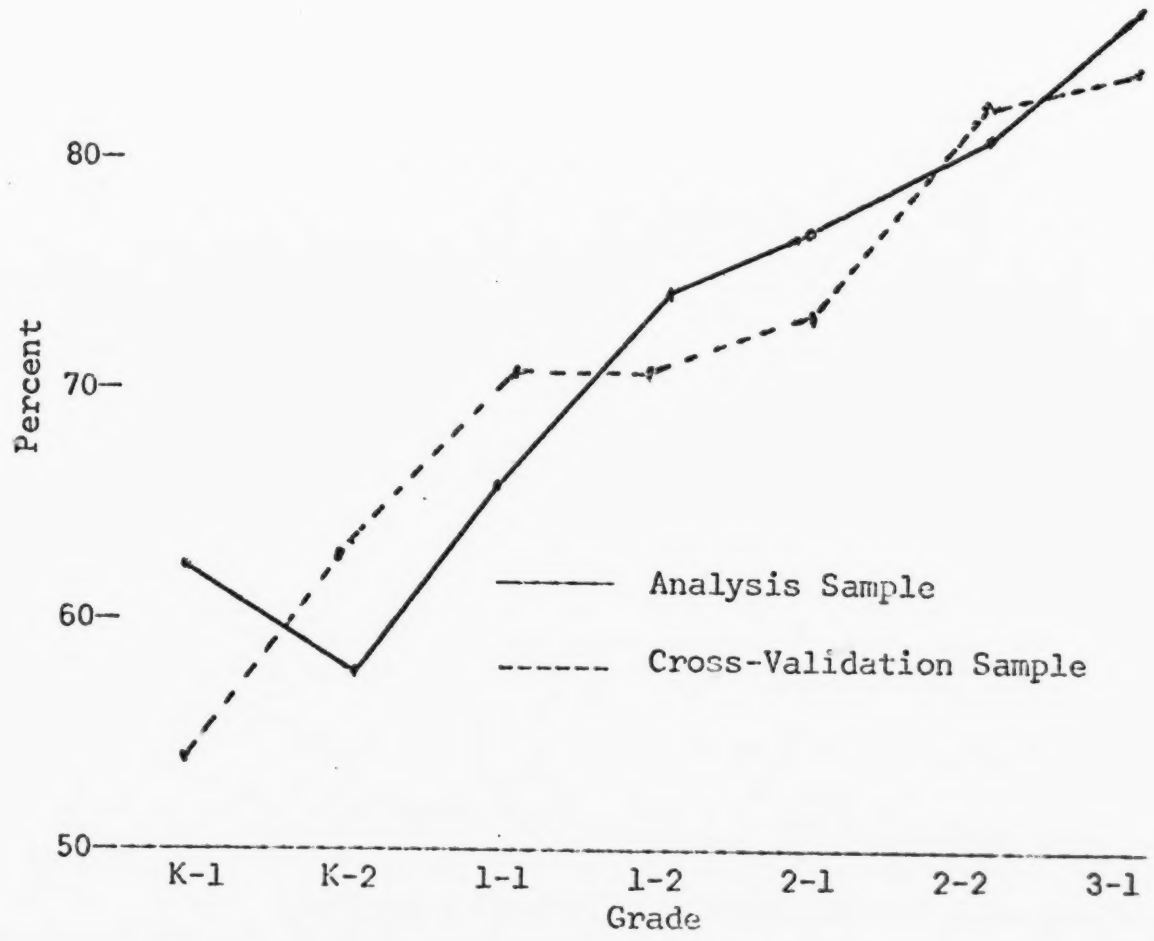
Figure 1. Pattern of Tests and Subtests in the Profiles.

Test or Subtest	Testing Period Profiles						
	Kgn.		1st		2nd		3rd
	K-1	K-2	1-1	1-2	2-1	2-2	3-1
Photo Articulation Test							
Items 1-9	1	2		4	5	6	7
Items 1-9 substitutions			3				7
All final items			3				
Items 3 and 6, substitutions			3				
Items 3 and 6				4	5		
Tongue omissions					5		
All substitutions						6	
Nonsense Syllable Test							
Items 1-5				4			
Sound Discrimination Test							
Unlike items	1						
Tongue Tip Examination							
Total score							7
Speech Mechanism Examination							
Swallow					5	6	
Lateral tongue movement				4			
Orthodontic Examination							
Grimace	1						
Openbite						6	7

more than one profile, the profiles usually represented successive testing periods. Figure 1 also shows that no single test or subtest, by itself, proved to be predictive at all testing periods, although a PAT subtest, items 1-9, was predictive at all but one period. The pattern suggested that, as the subjects' ages changed, different factors became predictors.

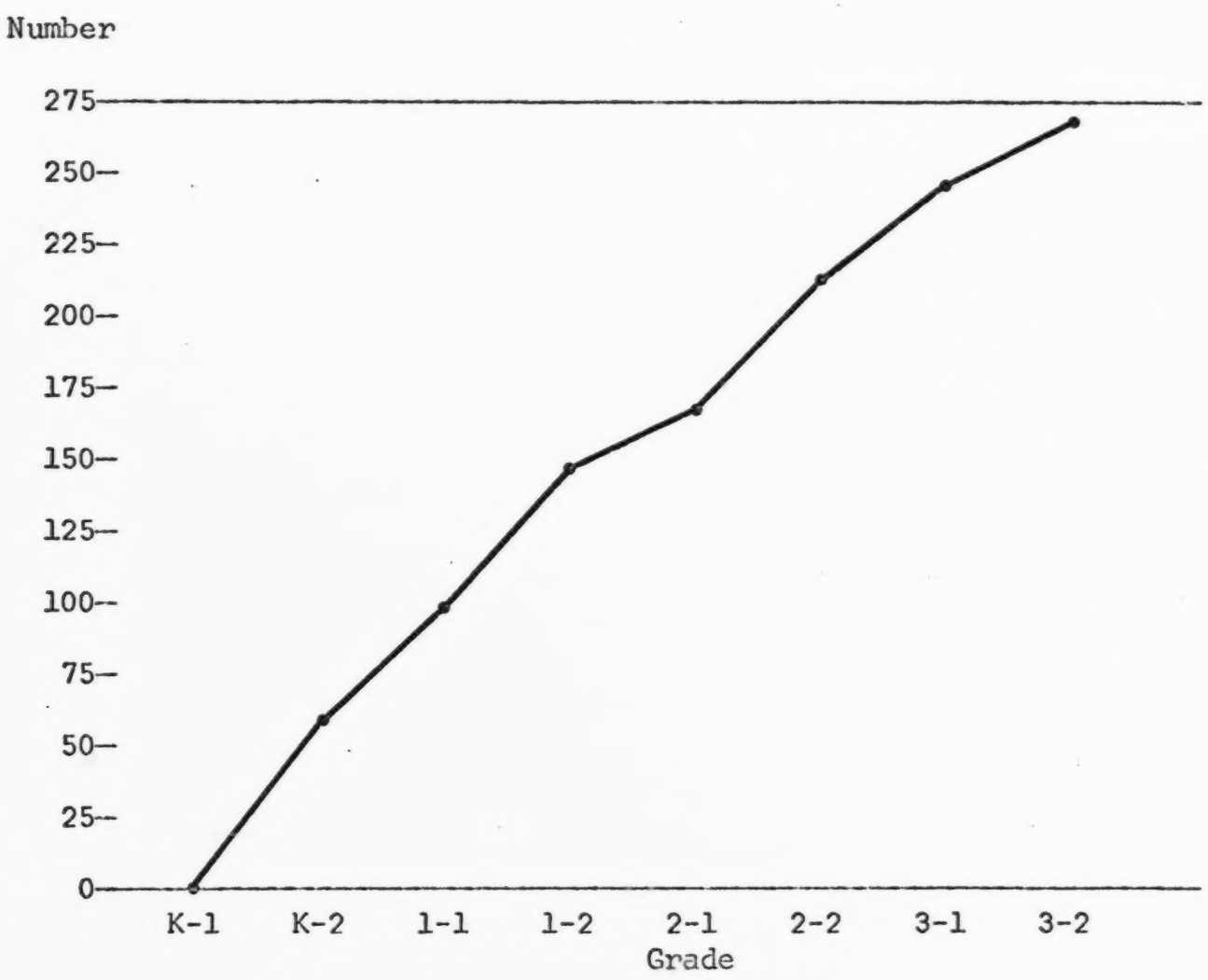
Figure 2 shows the percentage of predictability by the profiles for each of the testing periods for the analysis and the cross-validation groups. Lower prediction for the cross-validation group occurred at the 1st, 4th, 5th, and 7th testing periods. Higher prediction occurred at the 2nd, 3rd, and 6th testing periods. This phenomenon can be understood by consideration of the statistical methods involved (Appendix C).

Figure 2. Percent of correct prediction by the profile for each testing period in the analysis and the cross-validation samples.



In the kindergarten population of 7,931 children, 1,043 (13%) had a protrusional lisp. This study was based on 475 subjects from that group. There were 132 boys (52.6%) who recovered, while 119 did not and 134 girls (60.0%) who recovered, while 90 did not. This difference was not significant. The final testing showed that 266 (56%) of the 475 subjects had recovered from the lisp without speech therapy. Figure 3 shows the number of subjects who had recovered by each testing period. This figure indicates a consistent rate of recovery from the beginning of kindergarten through the end of third grade.

Figure 3. Number of children who recovered from a protrusional lisp without speech therapy at each testing period.

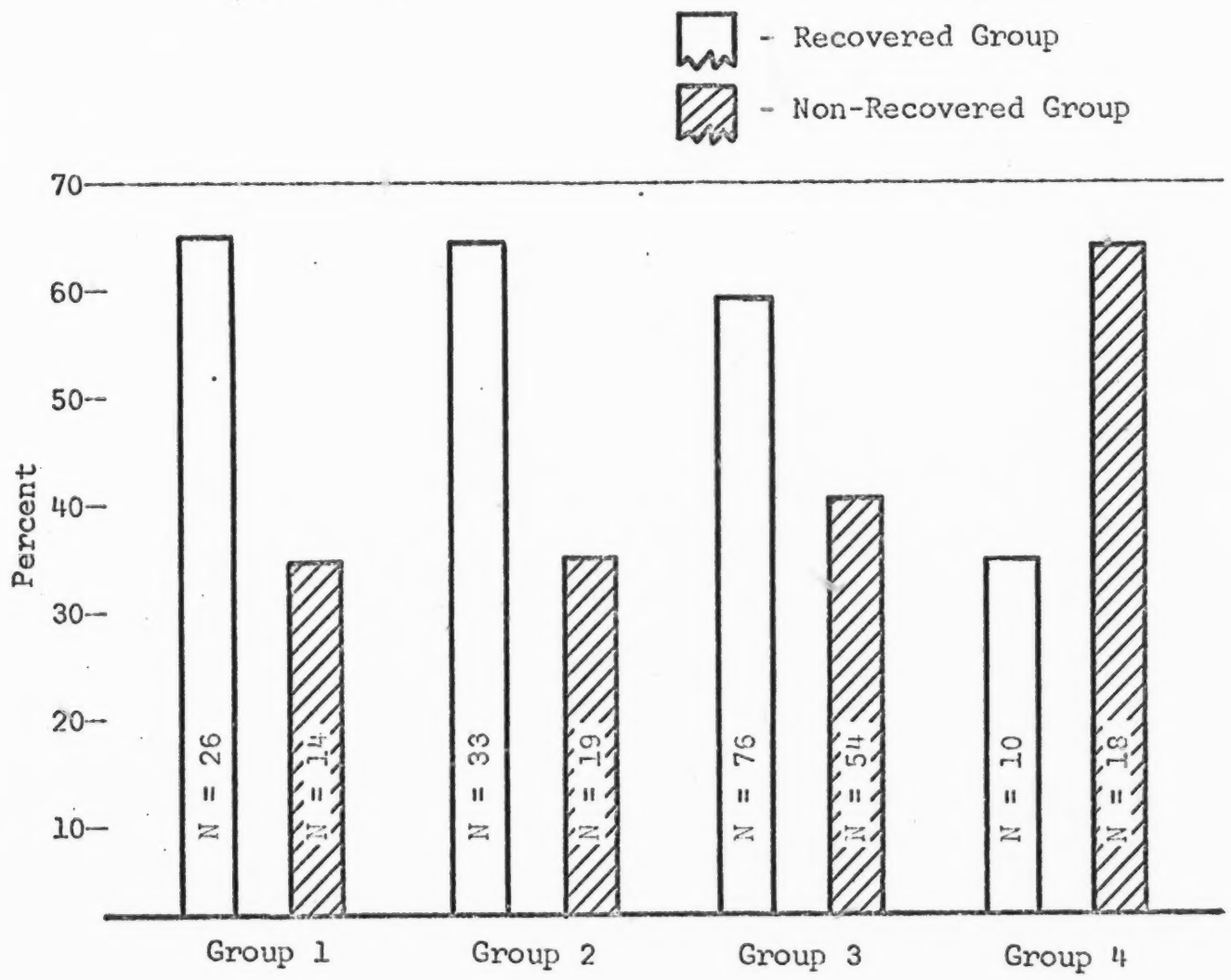


The data from the PAT was examined carefully because as much specific information about articulation as possible was desired. This examination included items 1-9 (the [s-z] items), items 3 and 6 (the final [s-z] items), items 10-46 and 53-60 (the other sounds articulated with the tongue), items 47-52 and 61-72 (the sounds articulated with the lips), and the entire test. The examination also included the type of error: omission, substitution, distortion, or a combination of these for each of the categories. Initial, medial, and final sounds were also examined.

The articulation patterns for the 250 subjects from the analysis group are shown in Figure 4. There were 40 subjects (16%) who entered the study with a protrusional lisp only. Of the 40 (Group 1), 26 (65%) recovered while 14 (35%) did not. There were 52 subjects (21%) who had a protrusional lisp and one or more errors on other sounds articulated with the tongue. Of the 52 (Group 2), 33 (64%) recovered while 19 (36%) did not. There were 130 subjects (52%) who entered the study with a protrusional lisp and one or more errors on sounds articulated with the lips. Of the 130 (Group 3), 76 (59%) recovered while 54 (41%) did not. There were 28 subjects (11%) who entered the study with a protrusional lisp and one or more errors on other sounds made with the tongue and sounds made with the lips. Of the 28 (Group 4), 10 (36%) recovered, and 18 (64%) did not. It is of interest to note that 65% of the subjects who entered the study with only a protrusional lisp (Group 1), recovered, while 64% of the subjects who entered the study with all types of articulation errors (Group 4) did not recover. Conversely, 35% of the subjects who entered the study with only a protrusional lisp (Group 1) did not recover, while 36% of the subjects who entered the study with all types of articulation errors (Group 4) did recover. The proportion of recovery between Group 1 and Group 4 is significantly different at the .01 level of significance. This result suggested that more kindergarten subjects who had only a protrusional lisp recovered by the end of third grade than subjects who had a protrusional lisp along with errors on other sounds articulated with the tongue and sounds articulated with the lips.

The rates of recovery or non-recovery for Groups 1, 2, and 3 shown in Figure 4 were very similar (35%, 36%, 41% for the non-recovery group and 65%, 64%, 59% for the recovery group). The rate of recovery or non-recovery for Group 4 was quite different. The rate of recovery was 36% which compared with the rate of non-recovery for the other three groups and the rate of non-recovery was 64% which compared to the rate of recovery for the other three groups. However, Group 4 represented only 11% of the analysis sample of 250 subjects and therefore the possible gain in prediction did not justify its separate analysis.

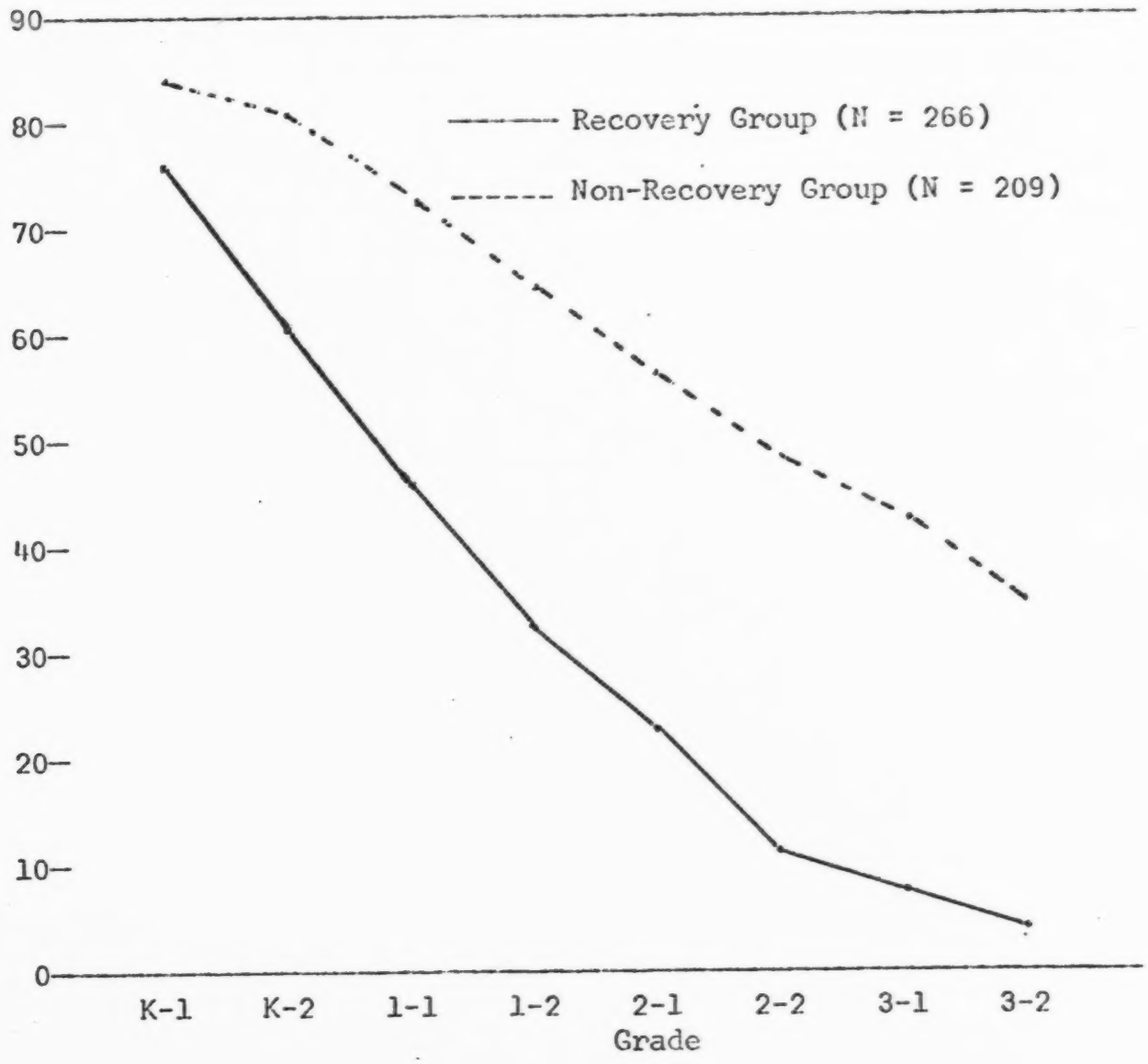
Figure 4. Differential rate of recovery for the 250 subjects in the analysis sample.



	Group 1	Group 2	Group 3	Group 4
	[s-z] errors only	[s-z] plus tongue sound errors	[s-z] plus lip sound errors	[s-z] plus tongue and lip errors
	N = 40	N = 52	N = 130	N = 28
Percent of 250	16%	21%	52%	11%

Figure 5 shows the percentage of subjects who had more than nine articulation errors on the PAT at each of the eight testing periods. Subjects in the recovery group tended to have a slightly less severe articulation problem when they began the study, as measured by number of sound errors, than did subjects in the non-recovery group. Subjects in the recovery group reduced the number of errors more rapidly than those in the non-recovery group. Further, the average number of errors on all sounds at the end of third grade was 1.3 for the recovery group and 10.5 for the non-recovery group.

Figure 5. Percent of subjects at each testing period having more than 9 errors on the PAT.



The Tongue Tip Examination showed that many subjects with a protrusional lisp produced [t, d, n, l] with the tongue blade, rather than the tongue tip. The percentages of blade production for these sounds in the test at the beginning of kindergarten were [t] 39%, [d] 41%, [n] 35%, and [l] 58%. The percentages of blade production decreased at each testing period as more and more subjects articulated these sounds with the tongue tip as usually described. At the end of third grade, the percentages of blade production were [t] 17%, [d] 15%, [n] 12%, and [l] 36%.

Even though the Tongue Tip Examination, by itself, did not efficiently predict recovery or non-recovery from a protrusional lisp, the results did yield information concerning recovery. When only the

subjects who were judged to have a relatively consistent production of [t, d, n, l], either tip or blade, were considered, the relationship between the manner of producing these sounds and recovery or non-recovery from a protrusional lisp was significant. The results from the Tongue Tip Examination were separated into two groups, tip and blade. The "normal" and "posterior" productions were considered tip, and the "anterior" and "down" productions were considered blade. The subjects who were inconsistent with an equal number of both tip and blade productions were disregarded. There were 253 subjects who produced [t, d, n, l] with the tongue tip at the first testing in kindergarten. Of this number, 155 subjects (61.3%) were in the recovery group. There were 150 subjects who produced [t, d, n, l] with the tongue blade at the first testing in kindergarten. Of this number, 75 subjects (50.0%) were in the recovery group. The difference between these two proportions was significant ($z = 2.04$ corrected for continuity, $p < .05$ two-tailed). This result suggested that the beginning kindergarten subjects with a protrusional lisp had a better chance to recover from the lisp without speech therapy if they produced [t, d, n, l] with the tongue tip rather than the tongue blade, as tested in this research.

The subjects in this study scored considerably higher than the published norms on the Peabody Picture Vocabulary Test. These scores suggested two possibilities. Protrusional lispers might have scored higher than non-lispers or Seattle Public School children as a total population sample might have scored higher than the group represented by the norms. To examine these possibilities, a group of one hundred non-lisping children was matched in proportion to the subjects in the study for grade, sex, age, and school. Form "B" of the PPVT was administered to this group under the same conditions as the group in the study. The scores of the two groups were almost identical, so it was concluded that the higher scores originally shown by the lispers merely reflected the difference between the Seattle Public School sample and the standardization sample.

CONCLUSION AND RECOMMENDATIONS

The data from many testing instruments were formulated into profiles designed to predict recovery or non-recovery from a protrusional lisp by the end of third grade. These profiles were compiled from the results of a group of testing instruments and were cross-validated on a subsample of the subjects. The seven profiles represented testing at six month intervals from the beginning of kindergarten through the beginning of third grade. A tongue tip examination and subtests from an articulation test, an orthodontic examination, a speech mechanism examination, a sound discrimination test, and a nonsense syllable test made up the profiles. Testing instruments which examined muscular control, psycholinguistic ability, social maturity, and intelligence were not found to be predictive in this research. None of the information on the school records or the questionnaire was predictive of recovery or non-recovery.

The pattern of tests and subtests in the profiles indicated that no single test or subtest, by itself, proved to be predictive at all testing periods. Each profile was predictive at only one testing period and the percentages of correct predictions increased with each successive profile.

The subjects remaining at the end of the study were randomly divided into an analysis sample and a cross-validation sample. The analysis sample was composed of a recovery group and a non-recovery group to establish cutoff scores and percentages of correct prediction for each profile. The profiles were then applied to the cross-validation sample to establish percentages of correct prediction for that group. The cutoff scores and the percentages of correct prediction are appropriate for the particular population tested and different figures might be more appropriate for other populations.

In addition to the profiles, this research provided general information about the subjects. Of the kindergarten population, 13% exhibited a protrusional lisp. By the end of the four years of the study, 56% of the subjects had recovered from their lisps without speech therapy. There was no significant difference between the number of boys and girls who recovered. The rate of recovery, based on numbers of subjects at each testing period, was consistent from the beginning of kindergarten through the end of third grade. More subjects who began the study with only a protrusional lisp recovered from the lisp than those who had a protrusional lisp along with errors on other sounds articulated with the tongue and sounds articulated with the lips. Subjects in the recovery group tended to have a slightly less severe articulation problem when they began the study, as measured by the number of sound errors, than did subjects in the non-recovery group. Subjects in the recovery group reduced the number of errors more rapidly than did subjects in the non-recovery group.

The examination of the production of [t, d, n, l] showed that many subjects with a protrusional lisp produced these sounds with the tongue blade, rather than the tongue tip, as usually described in the

literature. Also, a significant number of subjects, who recovered, produced [t, d, n, l] with the tongue tip rather than the tongue blade.

The results of this study suggest areas for further research. A large percentage of the kindergarten subjects with protrusional lisps articulated [t, d, n, l] differently than usually described, so research might determine if the general kindergarten population also articulates these sounds in the same manner.

The profiles might be tested on other populations of kindergarten through third grade subjects to determine predictability of recovery and non-recovery from a protrusional lisp. If these profiles could be shown to identify children who will spontaneously correct their protrusional lisps without therapy, on populations other than the cross-validation sample, the clinician's time could be used more profitably with those who will retain the lisp.

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APPENDIX A

TESTS AND INSTRUCTIONS

SEATTLE PUBLIC SCHOOLS
ADMINISTRATIVE AND SERVICE CENTER
815 FOURTH AVENUE NORTH
SEATTLE, WASHINGTON 98109
Special Education Department
Speech Therapy

PL-1

October 16, 1964

Dear_____

Your child has been chosen to participate in a four-year project to learn more about the speech sounds of school children. The United States Department of Health, Education, and Welfare has agreed that this information is important and has provided a grant for this purpose.

With your approval, your child will be given various speech and language tests every six months during the time of this study. A dental examination will be given by members of the Department of Orthodontics from the University of Washington Dental School. In addition, there will be thorough speech and hearing examinations administered by therapists in the Special Education Department, Seattle Public Schools.

If you have any questions about your child's participation in this project, please call Kathleen Pendergast, Supervisor of Speech and Hearing, AT 3-0900, Ext. 416.

Thank you for your cooperation.

Kathleen Pendergast
(Mrs.) Kathleen Pendergast
Supervisor of Speech and Hearing

Please cut on the dotted line and return the lower portion in the enclosed stamped, self-addressed envelope by OCTOBER 23.

I am willing to have my child participate in the Seattle Public Schools study of speech sounds.

Yes_____ No_____

_____ _____
Child's Name Signature of Parent or Guardian

_____
School

SEATTLE PUBLIC SCHOOLS PL-2
Administrative and Service Center
815 - 4th Avenue North
Seattle, Washington 98109
Special Education Department
Speech Therapy

Name of Child _____

School _____

Family information:

Father: Occupation _____ Birthplace _____

Years lived in Seattle _____

Mother: Occupation _____ Birthplace _____

Years lived in Seattle _____

Language other than English spoken in home _____

Names of other children in family	Ages of other children	Grade

(Use reverse side if necessary.)

Information about your child in the study:

Birthplace _____ Years lived in Seattle _____

Age he began walking _____ Age he began talking _____

Have his tonsils been removed? Yes / / No / / Are adenoids removed? Yes / / No / /

Does he have colds? Often / / Once in awhile / / Seldom / /

Does he have any allergies? Yes / / No / / Asthma? Yes / / No / /

Was he breast fed? Yes / / No / / If yes, until what age? _____

Was he bottle fed? Yes / / No / / If yes, until what age? _____

Name of Child_____

School_____

Does he refuse food that is difficult to chew? Yes ☐ No ☐

If yes, which foods_____

Has he ever sucked his thumb? Yes ☐ No ☐ At what age did he stop?_____

Does he still suck his thumb? Yes ☐ No ☐

Has he ever sucked a finger? Yes ☐ No ☐ At what age did he stop?_____

Does he still suck a finger? Yes ☐ No ☐

Has he sucked his lip? Yes ☐ No ☐ At what age did he stop?_____

Does he still suck his lip? Yes ☐ No ☐

Has he sucked his tongue? Yes ☐ No ☐ At what age did he stop?_____

Does he still suck his tongue? Yes ☐ No ☐

Has he sucked anything else, such as a blanket, a fuzzy toy? Yes ☐ No ☐

Does he still suck a blanket or toy? Yes ☐ No ☐ At what age did he stop?___

_____

Signature of Parent or Guardian

SEATTLE PUBLIC SCHOOLS
Special Education Department
Speech Therapy

PL-3a

INSTRUCTIONS FOR ADMINISTERING THE SCREENING TEST

Test Sentence: She lives in a little red house with her brothers and sisters.

1. Explain to the teacher what you plan to do and ask her to list the names of the children you indicate by your pre-arranged signal.

2. Tell the class, "I am going to play a game with you to see if you can remember this sentence."

    a. Tester says test sentence twice.
    b. Children say sentence in unison.
    c. Tester repeats sentence.
    d. Children again repeat sentence in unison.

3. Go to each child and listen to him say the test sentence. Indicate to the teacher by your signal those children who will be given the Photo Articulation Test. It is permissible to repeat the sentence for the child if he forgets.

SEATTLE PUBLIC SCHOOLS
Special Education Department
Speech Therapy

PL-3b

INSTRUCTIONS FOR ADMINISTERING THE FIRST PHOTO ARTICULATION TEST

After the kindergarten screening test, take each child whom you think has a protrusional lisp to your speech room. With no other child present, administer the first six items of the Photo Articulation Test using the following method.

1. Place the closed book in front of the child and say, "I am going to show you some pictures. As I point to each one, tell me what it is." Open the Photo Articulation Test book to page one and point to each picture in the same sequence as the words appear on the test form. Start at the top and move from left to right.

2. Make a check in the "Omitted" column if the sound is omitted.

3. Record the phonetic symbol if a sound is substituted.

4. Make a check in the "Distorted" column if a sound is distorted.

5. If the picture is named incorrectly, tell him the correct word, ask him to repeat it and score his response.

6. If the child exhibits a protrusional lisp on any of the first six items, administer the rest of the Photo Articulation Test.

7. Test item number 13 [ʒ] in the medial position only. Ask the child to repeat the word "measure" and score his response.

SEATTLE PUBLIC SCHOOLS PL-3c
Special Education Department
Speech Therapy

INSTRUCTIONS FOR ADMINISTERING THE PHOTO ARTICULATION TEST

Give the complete PAT to each child.

1. Place the closed book in front of the child and say, "I am going to show you some pictures. As I point to each one, tell me what it is." Open the Photo Articulation Test book to page one and point to each picture in the same sequence as the words appear on the test form. Start at the top and move from left to right.

2. Make a check in the "Omitted" column if the sound is omitted.

3. Record the phonetic symbol if a sound is substituted.

4. Make a check in the "Distorted" column if a sound is distorted.

5. If the picture is named incorrectly, tell him the correct word, ask him to repeat it and score his response.

6. Test item number 13 [3] in the medial position only. Ask the child to repeat the word "measure" and score his response.

PL-3

SEATTLE PUBLIC SCHOOLS
Special Education Department
Speech Therapy

School No._____ Child No._____

PHOTO ARTICULATION TEST

Name _____ Grade _____ Date _____

School _____ Room _____ Tester _____

Make a check if a sound is omitted or distorted. Record the phonetic symbol if a sound is substituted.

	Omit.	Sound Sub.	Dist.		Omit.	Sound Sub.	Dist.		Omit.	Sound Sub.	Dist.
[s] 1. saw				2. pencil				3. house			
[z] 4. zipper				5. scissors				6. keys			
[s] bl. 7. spoon				8. skates				9. stars			
[ʃ] 10. shoe				11. station				12. fish			
[ʒ]				13. measure							
[tʃ] 14. chair				15. matches				16. witch			
[dʒ] 17. jars				18. orange juice				19. orange			
[t] 20. tire				21. potato				22. light			
[d] 23. dog				24. ladder				25. bed			
[n] 26. nails				27. bananas				28. can			

PHOTO ARTICULATION TEST

	Omit.	Sound Sub.	Dist.		Omit.	Sound Sub.	Dist.		Omit.	Sound Sub.	Dist.
[l] 29. lamp				30. balloons				31. bell			
[l] bl. 32. blocks				33. clock				34. flag			
[θ] 35. thumb				36. toothbrush				37. teeth			
[ð] 38. this that				39. feathers				40. hat			
[r] 41. radio				42. carrots				43. car			
[r] bl. 44. brush				45. crayons				46. train			
[f] 47. fork				48. elephant				49. knife			
[v] 50. vacuum				51. TV				52. stove			
[k] 53. cat				54. crackers				55. cake			
[g] 56. gun				57. wagon				58. egg			
[ŋ]				59. finger				60. swing			
[p] 61. pipe				62. apples				63. cup			
[b] 64. book				65. baby				66. crab			
[m] 67. monkey				68. hammer				69. comb			
[w-hw] 70. windows				71. sandwich				72. whistle			

eh

SEATTLE PUBLIC SCHOOLS
Special Education Department
Speech Therapy

INSTRUCTIONS FOR ADMINISTERING THE NONSENSE SYLLABLE TEST

1. Give this test for only those sounds missed on the PAT. If an error was recorded on a sound in any position -IMF- on the PAT, test that sound in all three positions on the Nonsense Syllable Test.

2. Say to the child, "Watch me carefully and say what I say." Do not direct the child's attention to specific sounds.

3. Say one syllable at a time using the vowel sound [α]. Have the child imitate you and score his responses on the test form. Take each sound in turn giving the Initial, Medial, and Final positions in that order.

4. If the child does not respond, repeat the instructions and/or syllables as often as necessary.

5. Score a correct response as one and an error as zero. Any consonant deviation from your presentation of the sound tested is an incorrect response. Vowel deviations are not errors.

SEATTLE PUBLIC SCHOOLS
Special Education Department
Speech Therapy

PL-4

School No. _____

Child No. _____

NONSENSE SYLLABLE TEST

Name _____ Grade _____ Date _____

School _____ Room _____ Tester _____

1. s	sɑ		ɑsɑ		ɑs		18. ð	ðɑ		ɑðɑ		ɑð	
2. z	zɑ		ɑzɑ		ɑz		18b. h	hɑ		ɑhɑ			
3. sp	spɑ		ɑspɑ		ɑsp		19. r	rɑ		ɑrɑ		ɑr	
4. sk	skɑ		ɑskɑ		ɑsk		20. br	brɑ		ɑbrɑ		ɑbr	
5. st	stɑ		ɑstɑ		ɑst		21. kr	krɑ		ɑkrɑ		ɑkr	
6. ʃ	ʃɑ		ɑʃɑ		ɑʃ		22. tr	trɑ		ɑtrɑ		ɑtr	
7. 3	3ɑ		ɑ3ɑ		ɑ3		23. f	fɑ		ɑfɑ		ɑf	
8. tʃ	tʃɑ		ɑtʃɑ		ɑtʃ		24. v	vɑ		ɑvɑ		ɑv	
9. dʒ	dʒɑ		ɑdʒɑ		ɑdʒ		25. k	kɑ		ɑkɑ		ɑk	
10. t	tɑ		ɑtɑ		ɑt		26. g	gɑ		ɑgɑ		ɑg	
11. d	dɑ		ɑdɑ		ɑd		27. ŋ	ŋɑ		ɑŋɑ		ɑŋ	
12. n	nɑ		ɑnɑ		ɑn		28. p	pɑ		ɑpɑ		ɑp	
13. l	lɑ		ɑlɑ		ɑl		29. b	bɑ		ɑbɑ		ɑb	
14. bl	blɑ		ɑblɑ		ɑbl		30. m	mɑ		ɑmɑ		ɑm	
15. kl	klɑ		ɑklɑ		ɑkl		31. w	wɑ		ɑwɑ			
16. fl	flɑ		ɑflɑ		ɑfl		31b. hw	hwɑ		ɑhwɑ			
17. θ	θɑ		ɑθɑ		ɑθ								

SEATTLE PUBLIC SCHOOLS
Special Education Department
Speech Therapy

PL-5a

INSTRUCTIONS FOR ADMINISTERING THE SOUND DISCRIMINATION TEST

Give this test individually with no other child present. Say to the child, "I am going to say two sounds for you. Tell me if they are the same or different. Let me show you what I mean. [sɑ bɑ]. Were those the same or different?" _____. "Yes, they were different." If an incorrect response or no response is given, say, "They were different, weren't they?" Then say, "[sɑ sɑ]. Were those the same or different?" _____. "Yes, they were the same." If the child still does not understand what to do, explain further using the following sound combinations until he understands the procedure: [sɑ mɑ, sɑ wɑ, sɑ sɑ, sɑ gɑ, sɑ kɑ].

To give the test, hold a piece of tagboard six to eight inches in front of your mouth so the child cannot see your lips. Say the sound pairs in the same order as they appear on the Sound Discrimination Test form. After the presentation of each pair, ask, "Same or different?" Maintain a standard pitch, intensity, quality, and time throughout all the sound pairs. Score the test and record the total correct responses in the box at the bottom of the test form.

If the child does not understand how to take the test, write "unable to test." If the child's answers are all in one column, write "perseveration." Score 0 in each instance.

SEATTLE PUBLIC SCHOOLS PL-5
Special Education Department
Speech Therapy

School No. _____ Child No. _____

SOUND DISCRIMINATION TEST

Name_____ Grade_____ Date_____

School_____ Room_____ Tester_____

sɑ	sɑ	S ☐	D ☐	1.
sɑ	dʒɑ	S ☐	D ☐	2.
sɑ	tʃɑ	S ☐	D ☐	3.
sɑ	sɑ	S ☐	D ☐	4.
sɑ	ʒɑ	S ☐	D ☐	5.
sɑ	sɑ	S ☐	D ☐	6.
sɑ	sɑ	S ☐	D ☐	7.
sɑ	sɑ	S ☐	D ☐	8.
sɑ	ʃɑ	S ☐	D ☐	9.
sɑ	zɑ	S ☐	D ☐	10.
sɑ	sɑ	S ☐	D ☐	11.
sɑ	sɑ	S ☐	D ☐	12.
sɑ	ðɑ	S ☐	D ☐	13.
sɑ	sɑ	S ☐	D ☐	14.
sɑ	θɑ	S ☐	D ☐	15.

TOTAL CORRECT ☐

SEATTLE PUBLIC SCHOOLS
Special Education Department
Speech Therapy

PL-6a

INSTRUCTIONS FOR ADMINISTERING THE TONGUE TIP EXAMINATION

With the child in a position enabling you to view his tongue placement, insert a one-fourth inch wooden coffee stirrer vertically between the molars on either side. Have the child bite on the stirrer in that position and repeat each phrase after you. It may be necessary to have the child repeat the phrases more than once and you may change your position as needed to accurately view the tongue placement. If the tongue position is ever deviant, score it as a deviation.

Circle one word to describe the position of the tongue tip as the sound is produced.

1. If the tongue tip approximates the alveolar ridge, circle "normal."

2. If there is any degree of tongue tip protrusion in front of the upper central incisors, circle "anterior."

3. If the tongue tip position is behind the alveolar ridge, circle "posterior."

4. If the tongue tip is in any position below the alveolar ridge, such as approximating the upper or lower central incisors without a protrusion in front of the upper central incisors, circle "down."

SEATTLE PUBLIC SCHOOLS PL-6
Special Education Department
Speech Therapy

School No. _____ Child No. _____

TONGUE TIP EXAMINATION FORM

Name_____ Grade_____ Date_____

School_____ Room_____ Tester_____

Sentences:

I tie it tight.

Normal Anterior Posterior Down

Daddy had a dog.

Normal Anterior Posterior Down

I knock any night.

Normal Anterior Posterior Down

I like a lake.

Normal Anterior Posterior Down

SEATTLE PUBLIC SCHOOLS PL-7
Special Education Department
Speech Therapy

SPEECH MECHANISM EXAMINATION

School No. _____ Child's No. _____

Name_____ Grade _____ Date_____

School_____ Room_____ Tester_____

1. FRENUM EXAMINATION

   a. Can raise tongue tip voluntarily Yes [ ] No [ ]

   b. Normal [ ]

   c. Anterior attachment prevents tongue tip movement [ ]

   d. Anterior attachment does not prevent tongue tip movement [ ]

2. PALATE

   a. Normal [ ] b. High and narrow [ ] c. Other [ ]

3. ALVEOLAR RIDGE

   a. Normal [ ] b. Wide [ ] c. Narrow [ ]

4. SWALLOW

   a. Has facial grimaces Yes [ ] No [ ]

   b. Tongue protrudes [ ]

   c. Tongue does not protrude [ ]

5. TEST OF LIP AND TONGUE MOVEMENT Total [ ]

6. TEST OF LATERAL TONGUE MOVEMENT Total [ ]

SEATTLE PUBLIC SCHOOLS
Special Education Department
Speech Therapy

PL-7a

SPEECH MECHANISM EXAMINATION

1. FRENUM EXAMINATION

Say, "Open your mouth as wide as you can." Touch the midline of the alveolar ridge with the end of a coffee stirrer. As you remove the stirrer, say, "Touch that spot with your tongue." If he is unable to raise his tongue voluntarily, use a tongue depressor to lift his tongue for the examination. On PL-7, score part (a) for each child. Also examine the frenum attachment and record your observations as b, c, or d.

b. Normal

c. Frenum attached and prevents voluntary tongue tip elevation to the alveolar ridge.

d. Frenum attached, but does not prevent voluntary tongue tip elevation to the alveolar ridge.

2. PALATE EXAMINATION

Examine and judge shape.

3. ALVEOLAR RIDGE EXAMINATION

Examine the alveolar ridge and judge the midline distance from the junction of the upper central incisors and the alveolar ridge, to its posterior border.

√

-more-

4. SWALLOWING EXAMINATION

Have the child take a sip of water and ask him to swallow. Watch for facial grimaces and record observations. Tell the child you are going to have him swallow again, but this time you are going to pull his lower lip down as he swallows. Observe his swallow and record observations.

5. TEST OF LIP AND TONGUE MOVEMENT

Say, "I want you to say the word 'Tippy'." (Child responds.) "Now say Tippy Tippy Tippy. (Child responds.) "When I say go, say 'Tippy' over and over as fast as you can until I say 'stop'. Ready, go." Using the stop watch, count the number of tippys in a five-second period and record the total. If the child does not understand the task, demonstrate as often as necessary in the previously described manner.

6. TEST OF LATERAL TONGUE MOVEMENT

Say, "I am going to see if you can move your tongue as I do. Watch me carefully so you will know what to do when it is your turn." Demonstrate by touching each corner of your mouth with your tongue tip. Very slowly make six successive tongue touches during the demonstration. Say, "Now, you do that." Make sure the child understands what to do. Say, "When I say go, see how many times you can do it. Keep going until I say stop." "Ready, go."

Keep your eye on the stop watch held beside the child's mouth and, with peripheral vision, observe (each touch during a five-second period.) Count each touch as a point and record the total.

ORTHODONTIC EXAMINATION PL-8

SCHOOL NO._____ CHILD NO._____

NAME_____ GRADE_____ DATE_____

SCHOOL_____ ROOM_____ TESTER_____

DOCTOR_____ ROLL NO._____ PICTURE NOS._____

ANTERIOR TEETH

Maxillary

Rc	Rb	Ra	a	b	c
R3	R2	R1	1	2	3

Mandibular

Rc	Rb	Ra	a	b	c
R3	R2	R1	1	2	3

OVERBITE

0-5 mm. _____

5+ mm. _____

OVERJET

0-3 mm. _____

3+ mm. _____

OPENBITE (ANTERIORS)

0 mm. _____

0-2 mm. _____

2+ mm. _____

ERUPTION STAGE $\frac{1/1}{1/1}$

Primary Denture_____ Half Eruption _____

Early Eruption _____ Full Eruption _____

MOLAR RELATION

Right					Left				
I	Inter-mediate	II_1	II_2	III	I	Inter-mediate	II_1	II_2	III

TONGUE

	Yes	No	Undecided
Swallow Thrust			
Facial Grimace			
Swallow Tooth Contact			

Characteristics:_____

SEATTLE PUBLIC SCHOOLS
Special Education Department
Speech Therapy

PL-9a

INSTRUCTIONS FOR SCHOOL RECORD INFORMATION

Obtain the following information from each child's white, permanent record card in his school.

1. Record the score for the Metropolitan Readiness Tests given in late kindergarten or early first grade.

2. Record the Lorge-Thorndike Scholastic Aptitude Test score given in late September or early October of the child's second grade. This is a non-verbal test and yields I.Q., percentile, and stanine scores.

3. Record the achievement scores which are from the Metropolitan Achievement Tests. There is a word discrimination score for the second grade and there are word knowledge and reading scores for the third grade.

4. Record total days absent for kindergarten, first, and second grades.

5. Record general health evaluation as found on the white card for the same three grades.

6. Record end-of-year subject grades for reading, language, and arithmetic in the appropriate blanks for kindergarten, first, and second grades.

7. Check "yes" or "no" as appropriate if the child has been an active case with the Home Visitor, has been seen by the Psychologist, has a health problem or has been enrolled in reading improvement class.

8. Put a line in a score space if no test score is available.

PL-9

SEATTLE PUBLIC SCHOOLS
Special Education Department
Speech Therapy

School No._____ Child No._____

SCHOOL RECORD INFORMATION

Name_____ Grade_____ Date_____

School_____ Room_____ Tester_____

Readiness Test %_____

Scholastic Aptitude I.Q._____ %_____ Stanine_____

Achievement Tests

	Word Know.		Word Disc.		Reading	
	%	Sta	%	Sta	%	Sta
9/66						
9/67						

	1964-65	1965-66	1966-67
Days Absent			
General Health			
Reading			
Language			
Arithmetic			

Home Visitor	Yes____ No____
Psychologist	Yes____ No____
Health Problem	Yes____ No____
Reading Improvement	Yes____ No____

SEATTLE PUBLIC SCHOOLS
Special Education Department
Speech Therapy

INSTRUCTIONS FOR ADMINISTERING VINELAND SOCIAL MATURITY SCALE

The following directions standardize the scoring and testing procedures for the Vineland Scale.

1. Use categories (+), (±), and (-) only.

2. Score Tasks 57 through 89.

3. When judging a task, a plus indicates the child performs as well as an average child at the age level of the task. For example, on task #89, "Performs responsible routine chores," a child may set the table, help his father wash the car, and water the flowers when asked to, but the key words are "is responsible for performing recurrent and variable work." Just because the child does some of these things, does not necessarily mean that he does them regularly on his own initiative as a twelve to fifteen year old might do them. As another example, consider task #73, "reads on own initiative." A child may look at the comics and read simple stories. However, a plus credit could be given only if the reading material were on 4th grade level and the child "made independent and effective use of the material for his own entertainment and information," as an eight or nine year old child would do.

4. Refer to the section in the manual on scoring to guide your judgments.

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GENERAL INFORMATION ON THE OSERETSKY TEST

1. Test the child at his age level only.
   If he is 5-6 to 6-5, give the six year level;
   if he is 6-6 to 7-5, give the seven year level;
   if he is 7-6 to 8-5, give the eight year level.

   To determine age level, subtract birthdate from current date as in the Peabody Test, with 16 days or more counting as another month.

2. On the Record Blank indicate the child's preferred hand in the space under age. To determine handedness, ask the child to pick up chalk or a pencil and print his name on a chalkboard or paper.

3. Conversion of the metric system to approximate feet and inches is given for the three testing levels. The proper subtests are indicated.

   Six year level
   Subtest
   2. Target height - meter and a half = 5 feet.
   3. Rope height - 20 cm = 8 inches.
   4. Drawn lines - 3 mm = less than 1/16 inch.

   Seven year level
   Subtest
   3. Walking line - 2 meters = 6 feet 7 inches.

   Eight year level
   Subtest
   3. Push matchbox - 5 meters = 16 feet 5 inches.
   4. Running - 5 meters = 16 feet 5 inches.

4. Caution in judging each task is necessary. This is gained from a careful study of the manual.

5. Time will be most efficiently used if 3 or 4 children at the same age level are tested at the same time. This reduces the time needed to explain the various tasks.

6. Score each task on the Record Blank and write the total score on the top of the first page. Two points are scored for each task. When done by each hand or leg, one point for each is scored in the proper column. If negative, score with "0".

APPENDIX B

SUBJECT ATTRITION

SUBJECT ATTRITION

Kindergarten Population, October, 1964		7931
Protrusional Lispers, October, 1964		1043
Attrition During Study		
No Parental Approval	149	
No Questionnaire Returned	23	
Excluded from School	5	
Moved from City	215	
Transferred to Private School	108	
Absent for Testing	45	
Enrolled for Therapy	20	
Parent Request	2	
Deceased	1	
Total Attrition		568
Subjects Remaining, May, 1968		475

APPENDIX C

STATISTICAL METHODOLOGY AND ANALYSIS

STATISTICAL METHODOLOGY AND ANALYSIS

The considerations which guided the selection of testing instruments have been described earlier in this paper. The considerations by which numbers were assigned to test responses will now be discussed. The purposes of assigning numbers to responses were: 1) to allow for convenient and space-saving representation of the raw data on punched cards (which also facilitated the computation of frequency distributions and descriptive statistics, e.g., total "scores"); and 2) to represent quantitative aspects of responses numerically so that the relationships of these responses to recovery or non-recovery from a protrusional lisp could be investigated by means of statistical procedures. Alternative scoring procedures (including numerical transformations such as the arcsin) appeared to be theoretically feasible in several instances. Where this was the case, the scores derived from each different procedure were related to the criterion (recovery or non-recovery) in a subsample (to be discussed below) of the experimental participants. The procedure which yielded the highest simple product-moment correlation with the criterion was retained and the other procedure(s) discarded. Some of the available information yielded purely qualitative information, e.g., language other than English spoken in the home. In each instance the relationship of such a variable to the criterion was examined by means of a contingency table. In no instance did such a variable increase the predictability of recovery by more than seven percent. On every occasion when such a variable was used in conjunction with a correlational procedure to predict the criterion, no gain in predictability over that produced by the correlational procedure alone occurred. Therefore all such variables were discarded for purposes of prediction.

The statistical procedure used to relate the several hundred "scores," i.e., numerical representations of responses or clusters of responses on the test instruments, to the criterion was multiple linear regression. Because the criterion was dichotomous, i.e., since a participant was judged to be <u>either</u> recovered <u>or</u> not recovered from his lisp, nonlinear relationships between predictors and criterion presented little difficulty. There is as yet no technology available which allows an investigator to determine which subset from among several hundred predictors will best predict the criterion in question unless all subsets are examined. However, there are several procedures which allow one to approximate a best subset with a reasonable expenditure of investigator effort and computer time. The technique used in this investigation is "stepwise" regression.

The variables considered for use in the regression equation were those which correlated $|.15|$ or more with the criterion. Such a value is significant at about the one percent level for the number of observations available. The number of variables thus entered into the multiple regression program (1) varied from five to 28. (With 28 variables, there are 2^{28} possible regressions.) The stepwise multiple regression works in the following fashion. The single variable with

the highest correlation with the criterion is selected. At each subsequent step a candidate variable is selected for addition to the regression equation if it effects a significant decrease in the residual sum of squares. Also at each step, the variables which have been included are examined to see if elimination of any one (or more) of them would cause a non-significant increase in the residual sum of squares. Any such variable (or variables) is deleted. The selection procedure stops when all variables included would cause a significant increase in the residual sum of squares if removed and no more candidate variables can be found whose inclusion in the regression would result in a significant decrease in the residual sum of squares. The significance level used varied in a small band (because of varying degrees of freedom and the fact that only one F could be specified around .05.

Stepwise regressions were performed to relate the variables measured on each of the seven testing occasions to the criterion measure taken 1968(2). The resulting 7 equations are given in Tables 1 through 7. The interpretation of these tables may be aided if Table 1 is used as an example. The variable to be predicted was the criterion of recovery (signified by the number "0") or non-recovery (signified "1"). Six predictor variables correlated $|.15|$ or more with the criterion and were introduced, together with the criterion, into the stepwise regression program. Three variables were found to significantly add to the predictability of the criterion when selected and to significantly increase the residual sum of squares (roughly, the degree of unpredictability) when discarded. They are the total number of the faulty productions of the [s] and [z] sounds on the first nine items of the Photo Articulation Test (PAT); the presence or absence of a facial grimace during swallowing, Orthodontic Examination (OE); and the number of correct responses to the unlike items on the Sound Discrimination Test (SDT). It may be well to note that these three variables are linearly independent, but it can be seen in other tables that variables which are not linearly independent are often used together as predictors of the criterion. This is contrary to the usual usage of the regression model and is justified by the fact that empirical evidence for the efficiency of the prediction equations has been obtained; basically it is the least squares aspect of the regression technique that is being utilized and not its parametric inferential properties. To return to the prediction equation, one would estimate a score on the criterion (designated $\hat{Y}$) by the following equation:

$$\hat{Y} = .254 + .070\ (PAT) - .147\ (OE) - .037\ (SDT).$$

The value, .254, is called the "intercept" and is a kind of weighted average of the three predictor variables and the criterion variable. Suppose that individual M had eight errors on the PAT, a facial grimace on the OE which was scored as 1, and three errors on the unlike items of the SDT. Then the predicted criterion value is:

$$\hat{Y}_M = .254 + .070\ (8) - .147\ (1) - .037\ (3)$$

$$= .254 + .560 - .147 - .111$$

$$= .556$$

Since the criterion can take values of only 0 and 1 and since .556 is closer to 1 than to 0, one might imagine that the prediction for person M would be non-recovery. This is not necessarily the case. The possible predicted scores can range from -.299, if PAT is zero, OE is 2, and SDT is 7, to .737. Therefore, one must search for the predicted value below which most scores belong to recovered persons. That is, one must hunt for the cut-off score which maximizes the number of correct predictions. This was accomplished by means of two separate computer programs (2, 3). In this case the cut-off score had a value of .44. By applying the rule that, for a score from the regression equation that was below this value recovery was predicted, and that for a score above this value non-recovery was predicted, 62.0 percent correct predictions were made. No other cut-off score gave such a high proportion of correct predictions.

It should be obvious that such a cut-and-try procedure allows one to take advantage of chance differences due to sampling variability to make more correct predictions than would be possible in an ordinary random sample. What is not so apparent is that any least-squares procedure such as the regression technique used here allows the same thing to happen. That is, fortuitous differences are always exploited to obtain the smallest sum of squared deviations between observed and predicted value of the dependent variable. Therefore, unless very large samples are used, prediction will ordinarily be better in an original ("analysis") sample than it will be in later ("cross-validation") samples. There are formulas which can be used to estimate the amount of "shrinkage" to be expected, but these depend upon average sampling variability and upon strict adherence to the model. It is usually better to obtain empirical data on the shrinkage by collecting a second sample of data and applying the original equation and cut-off score to it (4). In this study, the 475 participants who remained in the study at the end of the final year were divided into an analysis group of 250 (upon whom trial scoring procedures were experimented with and from whom variables were selected and a cut-off score was found) and a cross-validation sample of 225. When the regression equation and cut-off score in Table 1 were applied to the cross-validation sample, the correct predictions dropped to 53.3 percent. Such shrinkage is typical, but greater values and even negative shrinkage, i.e., gain, in the cross-validation sample will occasionally occur due to sampling variation.

In viewing Tables 1 through 7, it is apparent that prediction is better as the testing year more closely approaches the criterion year. This is the expected finding, of course. The participants are more like their criterion selves the closer a testing year is to the criterion measurement.

STATISTICAL METHODOLOGY AND ANALYSIS REFERENCES

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